Space Weather Technical Forecast

Issued on Thursday, 21 December 2023 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of isolated M-class flares throughout, risk decreasing slightly from Day 3 (23 Dec).

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar Activity is Low, with background irradiance at C-class with occasional C-flares and a peak flare a C8.4 at 20/0854 UTC from AR3521. Eleven sunspot regions feature on the visible disc, with two unnumbered regions that are emerging in the eastern hemisphere. AR3524 and AR3525 have faded to plage. AR3529 (Eko/Beta-Gamma) in the southeast is the largest spot on the disc and remains one of the more complex regions, and is the currently the most active region. AR3521 (Dsi/Beta) has spread horizontally through 20 Dec and has shown some growth and decay of intermediate spots. AR3519 (Dai/Beta-Gamma) in the southwest has displayed minor evolution with ongoing penumbral growth observed around a north-south aligned central portion. The remaining regions are all comparatively smaller or magnetically simple.

No Earth-directed coronal mass ejections have been observed in coronagraph imagery. However, a flare from a region in the southeast around 20/2130 UTC appears to have produced a CME which will be analysed if and when imagery becomes available.

Solar Wind / Geomagnetic Activity: The solar wind environment was characteristic of the waning influence of a recent connection to the high speed stream of coronal hole 82, with a glancing blow of a weak CME from 15 Dec around 20/0000 UTC. Solar wind as measured by ACE at L1 were initially strong, around 600 km/s, but began declining around 20/0400 UTC and since 20/1200 UTC have remained at slightly elevated levels, around 420-450 km/s. Speeds measured by DSCOVR are slightly higher, and are currently stable and around 480km/s. Density was initially below average, increasing to average around 20/0800 UTC where it has predominantly remained. The IMF was weak throughout, and after an initial jump to 8nT at 20/0030 UTC, has declined and become stable. The north-south component of the IMF (Bz) has been predominantly negative, varying weakly +6/-8nT. The phi angle was mostly positive (away from the Sun), but has seen very brief periods of negative phi (towards the Sun). The resultant geomagnetic activity was largely Quiet to Unsettled (Kp 1-3), but with an Active (Kp4) interval from 20/0000-0300 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels.

GOES16 high energy (greater than 2MeV) electron flux was mostly at normal background to moderate levels, but has seen an upwards trend since 20/1200 UTC. The 24-hour fluence was well below the Active threshold (1e8 integrated pfu) on a steeply rising trend. The observation at 21/0000 UTC was 1.86e7 integrated pfu.

Four-Day Space Weather Forecast Summary
Solar Activity: Low with a chance of becoming Moderate with isolated M-class flares.

Solar Wind / Geomagnetic Activity: No Earth directed CMEs feature in the forecast period.

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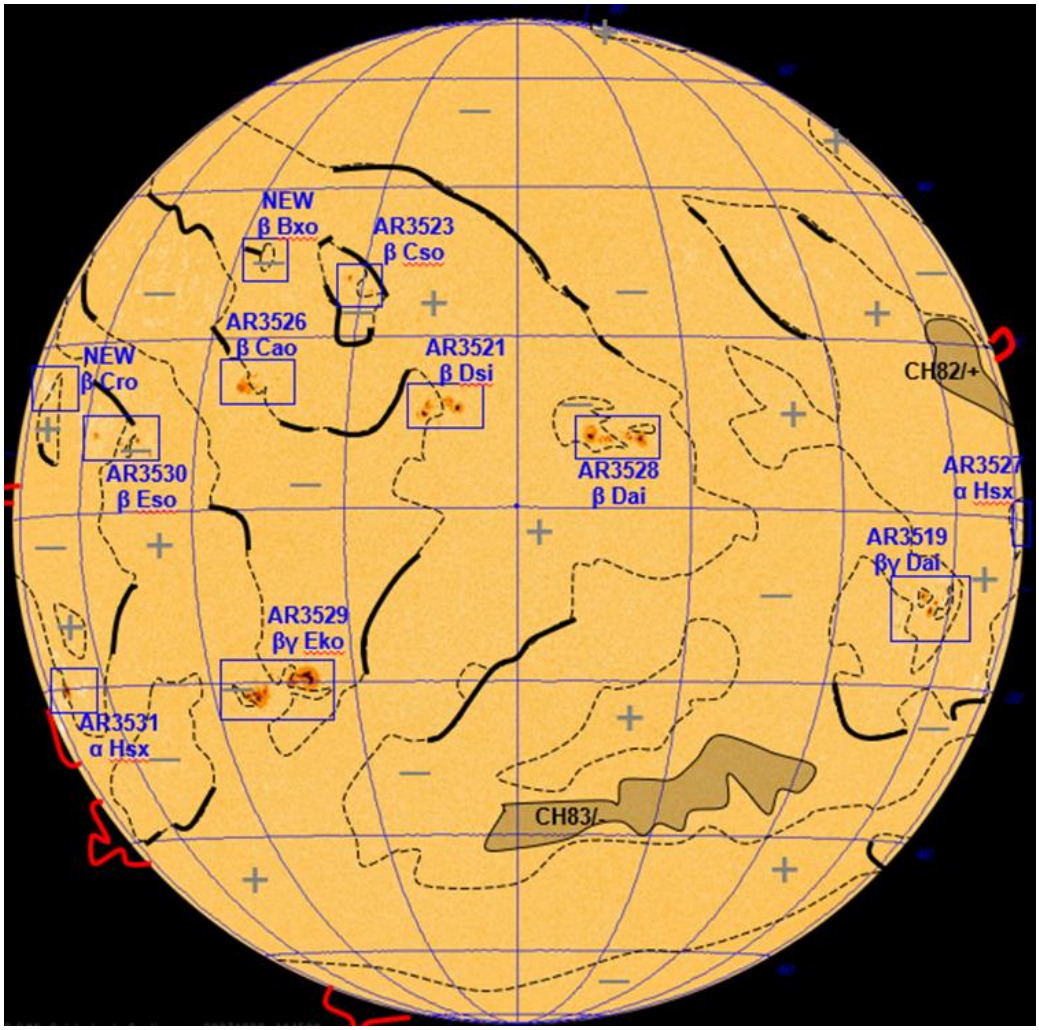
Wind speeds are expected to be initially at slightly elevated or slow ambient levels Day 1 (21 Dec). The next potential HSS enhancement is from CH83/- late Day 1 or more probably Day 2 (22 Dec). Speeds could peak between slightly elevated and strong levels. Winds should trend back towards background levels from Day 3 (23 Dec).
Geomagnetic activity is expected to remain largely Quiet to Unsettled (Kp 0-3) during the period. There is a chance of peak Active (Kp 4) conditions and a slight chance of a G1/Minor Geomagnetic Storm (Kp 5) interval upon uncertain connection to a high speed stream Day 1 or 2.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is at Background levels and expected to remain at similar levels.
High energy electron flux is expected to remain predominantly at Background to Moderate levels, with diurnal peaks at High levels Days 1-2 (21-22 Dec). Flux levels may reach more persistently High levels on subsequent days, although this depends strongly on the potential arrival of the coronal hole high speed stream by Day 2 which may supress electron levels. Active electron fluence is considered unlikely, although low confidence Days 3-4 (23-24 Dec).

Figure 1. Solar Analysis Valid 20/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No Earth directed CMEs feature in the forecast. However, flare activity from AR3529 around 20/2130 UTC may have produced a CME which will be analysed if it appears on coronagraph imagery in the coming hours.

Recent enhancement from connection to a HSS from CH82/+ has since waned, with speeds declining to slightly elevated levels. Speeds may ease further through Day 1 (21 Dec) to slow-ambient levels. A HSS from CH83/- may provide enhancement of solar winds from late Day 1 or Day 2 (22 Dec). If it were to become geo-effective, speeds could peak between slightly elevated and strong levels with influence waning Days 3-4 (23-24 Dec). In the absence of HSS enhancement, winds may remain at slow-ambient or slightly elevated levels throughout.

This is a recurrent feature, though appears larger and darker than previous rotation and may become geo-effective in the coming days. The corresponding period on the previous rotation in late November was heavily influenced by the arrival of multiple CMEs and this may have masked any connection to the coronal hole at the time. Consequently, confidence in the timing and extent of any connection to this feature is low. Given the coronal hole's southerly location (mainly between 30S-40S) on the disc and proximity to the solstice, any geomagnetic effects or enhancements are expected to be limited.

Geomagnetic activity should remain largely Quiet to Unsettled during the period. There is a chance of peak Active conditions and a slight chance of an isolated G1/Minor Geomagnetic Storm interval should connection to the arrival of the high speed stream of CH83/- occur late Day 1 or Day 2.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

No CMEs currently expected.

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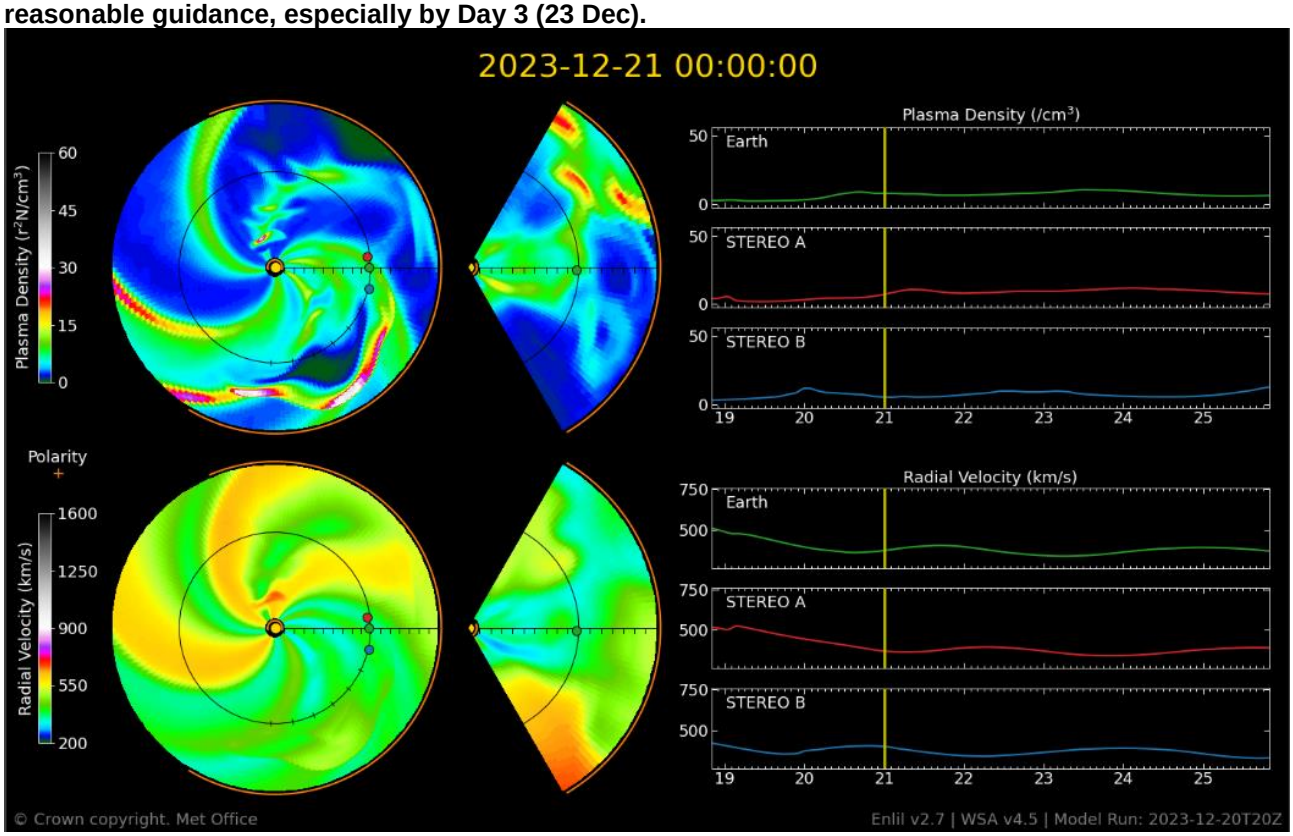
Figure 2: MOSWOC Enlil showing only minor enhancment from any HSS enhancement. Considered reasonable guidance, especially by Day 3 (23 Dec).



Radio Blackouts - X-Ray Flares:

Although current activity is Low, there remains a daily chance of isolated M-class flares, mainly from AR3521, AR3528 or AR3529.

There are currently eleven sunspot regions on the visible disc. AR3529 in the southeast is the largest spot on the disc, and remains one of the more complex. AR3528 in the northwest is the second largest region with ongoing evolution. AR3521 in the northeast has declined slightly since the last assessment. AR3519 in the southwest has displayed minor growth and beta-gamma magnetic configuration, penumbral growth has been observed around a north-south aligned central portion. A new and unnumbered region in the northeast continues to emerge from the eastern limb, though appears relatively small and simple at this stage. The remaining regions are all relatively small and/or magnetically simple with only minor growth or decay observed.

AR3527 will rotate beyond the western limb on Day 1 (21 Dec) with AR3519 set to depart on Day 3 (23 Dec). No new active regions are currently expected to arrive around the eastern limb in the forecast period. This is reflected by the slight decrease in flare probabilities towards the end of the period.

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X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	50	50	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES16 & GOES18 X-Ray trace over the past 24 hours

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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is at normal background levels and expected to remain at similar levels in the absence of significant flare activity. The risk of minor solar-radiation storms increases slightly as spots currently in the eastern hemisphere rotate into a more geo-effective position.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux is at largely background to moderate levels with an increasing trend observed through 20 Dec. Diurnal peaks at High levels are likely Days 1-2 (21-22 Dec), with more persistent periods at High levels possible as the solar wind pressure subsides and the Van Allen belts relax towards background again. Connection to a HSS may lead to electron flux levels becoming suppressed by Day 3 (23 Dec), however, if this connection doesn't occur diurnal periods at High levels may continue Days 3-4 (23-24 Dec).

There is high confidence that electron fluence will remain below the Active (1e8 integrated pfu) threshold on Day 1. From Day 2 onwards Active fluence is not expected, but carries low confidence, with a slight chance of exceeding threshold values. Uncertainty in the forecast increases Days 3-4 given the low confidence in any connection to a HSS. REFM is currently considered to be giving good guidance, by Day 3 confidence reduces.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	10	10	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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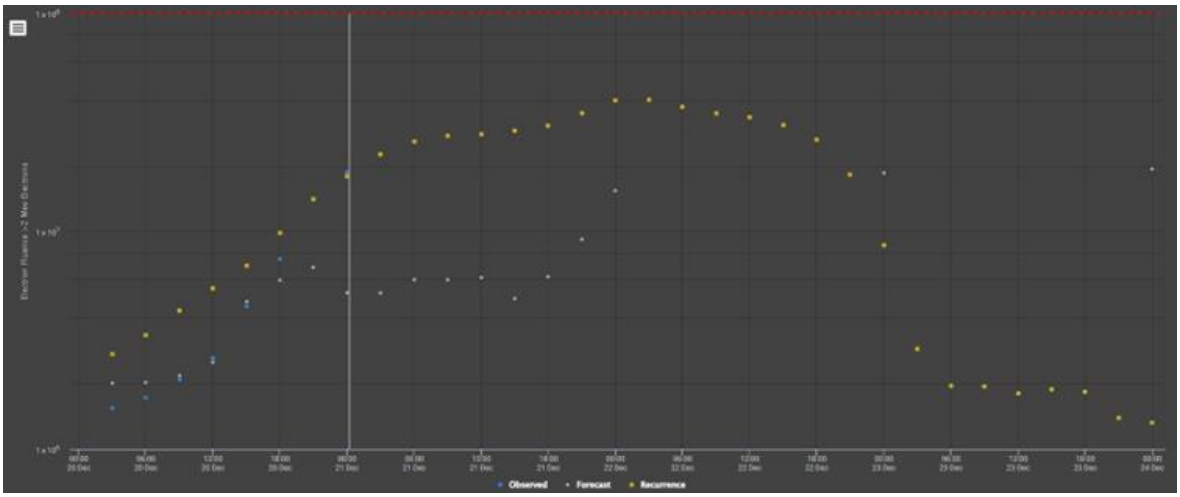
Figure 4: REFM thought to be giving good guidance. Low confidence Day 3 onwards (23 Dec)



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